

**AUTOMATIC TESTER DEVICE FOR EARTH LEAKAGE CIRCUIT
BREAKER**

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ABSTRACT

Power system protection plays important role for the safety of humans and electrical equipments in houses or buildings. Besides it also becomes a precondition of the system for obtaining capability and continuous power supply. Earth leakage circuit breaker (ELCB) is an important protection device especially for houses and buildings. The ELCB's spring trap will trip to isolate the fault from the system when line to ground fault occurs. So the good condition of the ELCB is very important to run the duty as a power system protector. This project is designed to test the earth leakage circuit breaker (ELCB) automatically every month by detecting current through it when it is in off condition. Microcontroller will be use in this project to make the ELCB automatically tested with programmed it for month. During test period, a current detector which is connected series with the ELCB will detect any current that flow through it. When the detector detect currents, mean that the ELCB does not function properly and LED or buzzer will be ON as an indicator for occupant, so that ELCB can be change immediately. The ELCB is in good condition and can function properly when no current detected and DC motor will be used to switch ON the ELCB's spring trap. Actually this project can improve the ELCB application and also will enhance the safety for occupant of houses and buildings.

CHAPTER 1

INTRODUCTION

1.1 Background

This chapter explains about the information of circuit breaker and also explains about identification of automatic tester device for ELCB, problem statement, objective of the project and project scope.

1.1.1 Circuit breaker

Circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Circuit breaker can be reset (manually) to resume normal operation. Basically, circuit breaker is implemented using a solenoid (electromagnet) that's pulling force increase with the current. There are many different technologies used in circuit breaker such as:

- i. Miniature Circuit Breaker (MCB)
 - Rated current not more than 100A.
 - Trip characteristics normally not adjustable.
- ii. Moulded Case Circuit Breaker (MCCB)
 - Rated current up to 1000A.
 - Thermal or thermal magnetic operation.
 - Trip current may be adjustable.
- iii. Residual Current Device (RCD)
 - Known as a Residual Current Circuit Breaker (RCCB).
 - Detects current imbalance.
- iv. Earth Leakage Circuit Breaker (ELCB)
 - This detects earth current directly rather than detecting imbalance.
- v. Residual Current Breaker with Overcurrent Protection (RCBO)
 - Combines the function of RCD and an MCB in one package.

1.1.2 Automatic tester device for ELCB

In this project, basically have 3 main circuits. First circuit is to make the ELCB trip automatically. Second's circuit is to checks current flow through the ELCB. Last circuit is to switch ON automatically the ELCB's spring trap using a dc

motor. All the circuits controlled by microcontroller, PIC 16F877A so that the operation of this project operates with directive and fluent.

1.1.3 Automatic ELCB's trip.

Application of this circuit basically for replace the function of test button 'T' at the ELCB which is use for trip the ELCB when it pushed manually. This circuit will trip the ELCB every month, so the microcontroller is programmed with timer program for a month and will send signal to relay when the timer has been counted for a month. Normally open at the relay connection connected with life wire (L) and neutral wire (N) from power supply. When the relay received signal from microcontroller, PIC16F877A, it will energized and short the normally open's connection. Basically ELCB will trip instantaneous when the life wire (L) and the neutral wire (N) are shorted because fault is created.

1.1.4 ELCB's current detector.

After the ELCB trip, it is in off condition, so to ensure it is in good condition or not, current detector will be use. If the current detector detects no current flows through the ELCB, microcontroller, PIC16F877A, will send signal to relays for control a DC motor to push back the ELCB's spring trap and the ELCB is in good condition. Otherwise, if it detects current, the ELCB's is not in good condition and microcontroller, PIC16F877A, will send signal to ON LED or Buzzer as an indicator.

1.1.5 Automatic switch on ELCB's spring trap.

The ELCB's spring trap actually will be pushed by a DC motor but with order from microcontroller, PIC16F877A. Microcontroller will ensure the ELCB is in good condition before it sends signaling to control a DC motor to push back the ELCB's spring trap.

1.2 Problem statement.

Normally ELCB should be tested monthly to ensure it is well functioning or not and the good condition of the ELCB make it's operating fluently as an earth leakage circuit breaker when fault occurs but the problems are:

- i. The ELCB is test manually using the test button 'T' on it.
- ii. Cannot ensure the good condition of the ELCB and cannot detect current flow through it.
- iii. After test period has been done, ELCB's spring trap should be push up manually.

1.3 Project objectives.

The overall of this project is to test the ELCB every month automatically using microcontroller, PIC16F877A. This project has three main objectives to achieve such as:

- i. Trip ELCB automatically every month.
- ii. Ensure the good condition of the ELCB with current detector.
- iii. Switch ON back the ELCB's spring trap automatically.

1.4 Project scope.

The scope of this project is:

- i. To design a hardware that can take duty only for test and turn on back the ELCB and at the same time ensure the good condition of the ELCB by using current detector. This project did not function during fault situation and when the ELCB detect leakage current and trip, the spring trap must turn on back manually after that.
- ii. To design and simulate program that will be use to setting time and date for every month as input to trip the ELCB and for controlling a DC motor for turn on back ELCB after test period.
- iii. Does not have any back up circuit when the ELCB in test progress because it is difficult for make appropriate back up circuit to take ELCB duty and the suitable circuit that can be use for back up is UPS (uninterruptible power supply) which is complicated to design.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction.

This chapter will review about the single phase system, function and principal operation of circuit breaker and also will discuss about application of residual current circuit breaker (RCCB). Then it will review about components of hardware and software that will be use to make this project.

2.1.1 Single phase system

Single phase electric power refers to the distribution of electric system using a system in which all the voltage of the supply varies in unison. Standard frequencies are either 50 or 60 Hz.

A single phase load may be powered from a three phase distribution system either by connection between a phase and neutral (120V or 220V). On higher voltage system (kilovolt), a single phase transformer is use to supply a low voltage system. Single phase power distribution is used especially in rural area, were the cost of a three phase distribution network is high. Typically, a third conductor is called a ground or earth use for safety, and ordinarily only carries significant current when there is a current fault.

Although the single phase system has safety (earth conductor) but this system can not perfectly protect the electrical circuit, electrical equipment and also human life from the high voltage. So, the circuit breaker is needed to make more protection. [1]



Figure 2.1: Single phase system.

2.1.2 Circuit breakers.

The device is use for open or closes an electric power circuit either during normal power system operation or during abnormal conditions. A circuit breaker serves in the course of normal system operation to energize or disenergize loads. During abnormal conditions, when excessive current develops, a circuit breaker opens to protect equipment and surroundings from possible damage due to excess current. These abnormal currents are usually the result of short circuits created by lightning, accidents, deterioration of equipment, or sustained overloads.

Formerly, all circuit breakers were electromechanical devices. In these breakers a mechanism operates one or more pairs of contacts to make or break the circuit. The mechanism is powered electromagnetically, pneumatically, or hydraulically. The contacts are located in a part termed the interrupter. When the contacts are parted, opening the metallic conductive circuit, an electric arc is created between the contacts. This arc is a high-temperature ionized gas with an electrical conductivity comparable to graphite. Thus the current continues to flow through the arc. The function of the interrupter is to extinguish the arc, completing circuit-breaking action. [2]

In oil circuit breakers, the arc is drawn in oil. The intense heat of the arc decomposes the oil, generating high pressure that produces a fluid flow through the arc to carry energy away. At transmission voltages below 345 kV, oil breakers used to be popular. They are increasingly losing ground to gas-blast circuit breakers such as air-blast breakers and SF₆ circuit breakers.

In air-blast circuit breakers, air is compressed to high pressures. When the contacts part, a blast valve is opened to discharge the high-pressure air to ambient, thus creating a very-high-velocity flow nears the arc to dissipate the energy. In SF₆ circuit breakers, the same principle is employed, with SF₆ as the medium instead of air. In the “puffer” SF₆ breaker, the motion of the contacts compresses the gas and forces it to flow through an orifice into the neighborhood of the arc. Both types of SF₆ breakers have been developed for EHV (extra high voltage) transmission systems.

Two other types of circuit breakers have been developed. The vacuum breaker, another electromechanical device, uses the rapid dielectric recovery and high dielectric strength of vacuum. A pair of contacts is hermetically sealed in a vacuum envelope. Actuating motion is transmitted through bellows to the movable.[3]

2.1.3 Circuit breaker operation.

Circuit breaker is implemented using a solenoid (electromagnet) that's pulling force increases with the current. The circuit breaker's contacts are held closed by a latch and, as the current in the solenoid increases beyond the rating of the circuit breaker, the solenoid's pull releases the latch which then allows the contacts to open by spring action. The core is restrained by a spring until the current exceeds the breaker rating. During an overload, the solenoid pulls the core through the fluid to close the magnetic circuit, which then provides sufficient force to release the latch. Short circuit currents provide sufficient solenoid force to release the latch regardless of core position thus bypassing the delay feature. Ambient temperature affects the time delay but does not affect the current rating of a circuit breaker. [4]

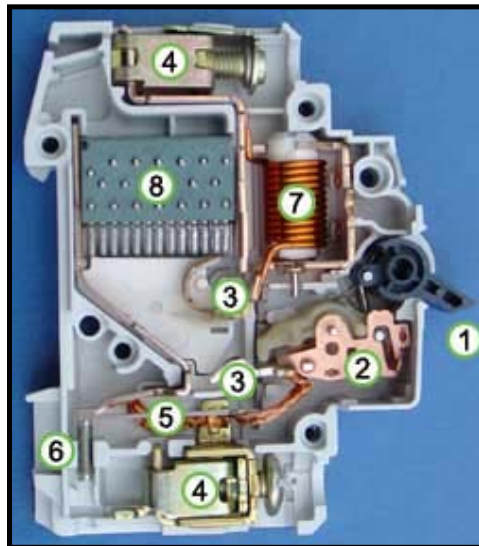


Figure 2.2: Internal of circuit breaker

1. Actuator lever - used to manually trip and reset the circuit breaker. Also indicates the status of the circuit breaker (On or Off/tripped). Most breakers are designed so they can still trip even if the lever is held or locked in the on position. This is sometimes referred to as "free trip" or "positive trip" operation.
2. Actuator mechanism - forces the contacts together or apart.

3. Contacts - Allow current to flow when touching and break the flow of current when moved apart.
4. Terminals
5. Bimetallic strip
6. Calibration screw - allows the manufacturer to precisely adjust the trip current of the device after assembly.
7. Solenoid
8. Arc divider / extinguisher

In this project, residual current circuit breaker (RCCB) is chosen because RCCB have several important characteristic as table the table below:

Table 2.1: Characteristic of residual current circuit breaker (RCCB).

Rated Voltage	230VAC (2 poles), 400VAC (4 poles)
Rated Current	25A, 40A, 63A
Rated Residual Operating Current	30mA, 100mA, 300mA, 500mA
Residual Current off-time	0.1s
Minimum Value of Rated Making and Breaking Capacity	1KA
Rated Condition Short Circuit Current	In = 25, 40A Inc = 1500A In = 63A Inc = 3000A

2.1.4 Residual current circuit breaker (RCCB)

Residual current circuit breaker (RCCB) is an electrical wiring device that disconnects the circuit whenever it detects flow of current is not balance between the phase conductor and the neutral (N) conductor as shown in Figure 2.3. The presumption is that such as imbalance may represent current leakage through the body of a person who is grounded and accidentally touching the energized part of the circuit. RCCB is designed to disconnect quickly enough to prevent such as shock. [4]



Figure 2.3: Residual current circuit breaker (RCCB)

2.1.5 RCCB operation.

RCCB operate by measuring the current balance between 2 conductors using a differential current transformer, and opening the device's contact if there is a balance fault (difference in current between the phase conductor and neutral conductor). RCCB operate by detecting a nonzero sum of current must equal zero (within some small tolerance), otherwise there is leakage of current to somewhere else (to ground or other circuit). Normally, RCCB is use to protect people to interrupt the circuit if the leakage current exceed a range 4 to 6 milliamps of current (the exact trip setting can be chosen by the manufacturer of the device and is typically 5 milliamps) within 25 milliseconds. Also, the RCCB is use to protect the electrical circuit and electrical equipment are allowed to trip as high as 30 milliamps of current. [4]

2.1.6 Principal operation of RCCB.

ELCB (earth leakage circuit breaker) or also known as RCCB (residual current circuit breaker) is use to detect leakage current and also provides protection against direct and indirect contact of personnel and livestock and against probable fires. ELCB should be test monthly to ensure it is in good condition or not using ELCB test button.

Principal operation of ELCB is in electrical circuit, the incoming current is the same as outgoing current as shown in Figure 2.4 below:

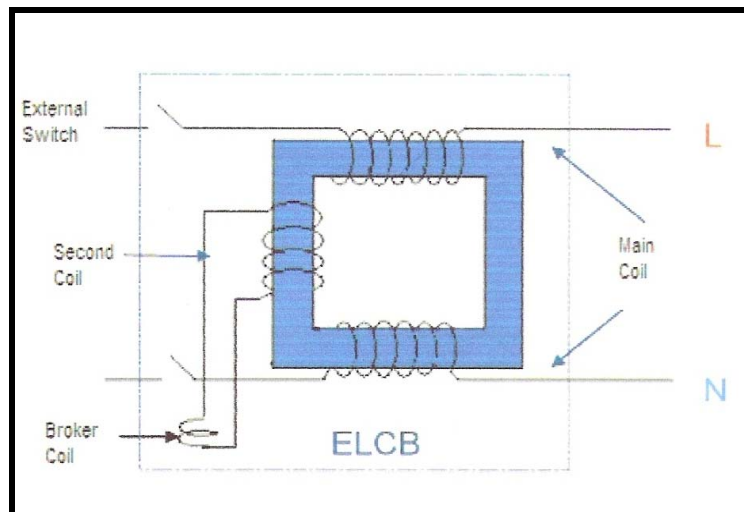


Figure 2.4: Principal operation of ELCB

Incoming current will flow through in life wire (L) and outgoing current will flow through out neutral wire (N) for make complete circuit. This operation is based on electromagnetic theory where incoming and outgoing current flowed through the wires will have their flux. This ELCB incorporates a core balanced transformer which is having main coil and second coil. The main coils have primary windings for life wire (L) and secondary windings for neutral wire (N) and the second coil which is connected to relay for instantaneous detection of fault. In faultless situation, the flux which is carried by incoming and outgoing current will cancel each others. There is no magnetic field or flux that could induce a voltage in second coil. During

flow of leakage current in the circuit an imbalance current is created because circuit is not complete and no outgoing current at the neutral wire (N) and imbalance flux that carried by the current cannot cancel each others and gives rise to unleakage flux in the core. This unleakage flux will interact with core and produce a magnet at second coil. The magnet at second coil will energize relay or broker coil and trips the external switch thereby disconnecting the supply.

RCCB is designed to prevent electrocution by detecting the leakage current, which can be far smaller (typically 5-6 milliamps) than the trigger current needed to operate conventional circuit breaker, which are typically measure in amperes. RCCB are intended to operate within 25 milliseconds. [5]

2.1.7 Flow operation of RCCB.

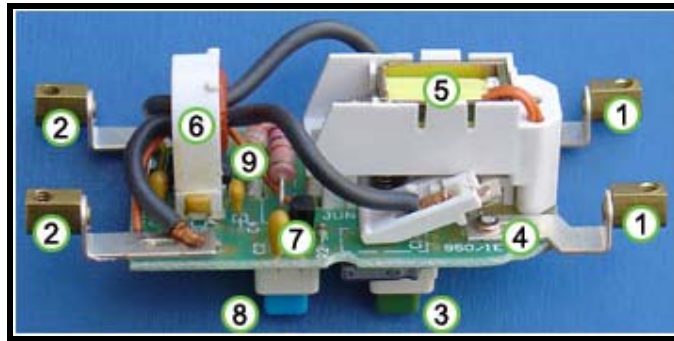


Figure 2.5: Internal mechanism of RCCB

The Figure 2.5 above is internal mechanism of RCCB. The device is designed to be wired in line in an appliance flex. It is rated to carry a maximum current is 13 amperes and is designed to trip on a leakage current of 30 amperes. Function for each terminal is described in Table 2.2.

The incoming supply live and the grounded neutral conductor are connected at terminal 1 and outgoing load conductors are connected at terminal 2. When the

reset button at terminal 3 is press the contact at terminal 4, allowing current to pass. The solenoid at terminal 5 keeps the contacts close when the reset button is released. The sense coil at terminal 6 is a differential current transformer which surrounds the live and neutral conductor.

Table 2.2: Portion each terminal of RCCB

Terminal	Portion
1	Grounded neutral conductor
2	Outgoing load conductor
3	Reset
4	Contact
5	Solenoid
6	Sense Coil
7	Sense Circuitry
8	Test Button
9	Test Wire

In normal operation, all the current flowing down the live conductor returns up the neutral conductor. The current in the 2 conductor are therefore equal and opposite and cancel each other out. When imbalance current flowing in the 2 conductor, this difference causes a current flowing in the sense coil at terminal 6 which is picked up by the sense circuitry at terminal 7. The sense circuitry then remove power from the solenoid at terminal 5 and the contact at terminal 4 are forced part by the spring, cutting off the electricity supply to the appliance. The device is designed so that the current is interrupted in a fraction of a second; greatly reducing the chances of dangerous electric shock being receive.

The test button at terminal 8 allows the correct operation of the device to be verified by passing a small current through the orange test wire at terminal 9. This simulates a fault by creating an imbalance in the sense coil. [4]

2.2 Hardware part.

This part will discuss about the components that will be use for make the hardware of this project and the components that list below are the main component which will make the hardware successfully run on based the design circuit.

2.2.1 Microcontroller (PIC 16F877A).

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC was originally an acronym for "Programmable Intelligent Computer".

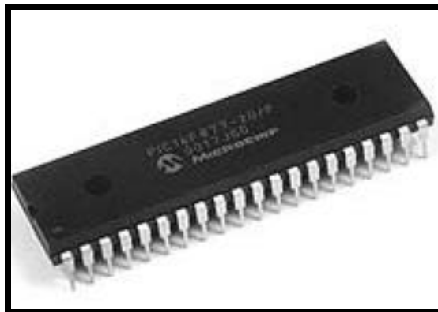


Figure 2.6: PIC16F877A

In this project, a microcontroller; PIC16F877a (Figure 2.4.1 (a)) is use to control the output. The reason for use microcontroller is the PIC architecture is distinctively minimalist. It is characterized by the following features:

- i. separate code and data spaces
- ii. a small number of fixed length instructions
- iii. most instructions are single cycle execution (4 clock cycles), with single delay cycles upon branches and skips
- iv. a single accumulator (W), the use of which (as source operand) is implied

- v. All RAM locations function as registers as both source and/or destination of math and other functions.
- vi. data space mapped CPU, port, and peripheral registers
- vii. the program counter is also mapped into the data space and writable (this is used to synthesize indirect jumps)
- viii. 10-bit multi-channel Analog-to-Digital converter
- ix. Has 33 input or output ports (see Figure 2.7).

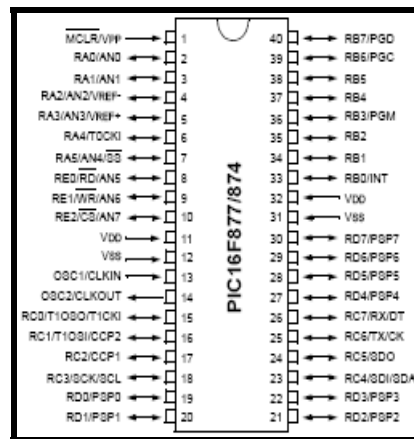


Figure 2.7: PIC 16F877A schematic

Unlike most other CPUs, there is no distinction between "memory" and "register" space because the ram serves the job of both memory and registers, and the ram is usually just referred to as the register file or simply as the registers.

PIC microcontroller have a very small set of instructions (only 35 instruction), leading some to consider them as RISC devices, however many salient features of RISC CPU's are not reflected in the PIC architecture. For example:

- i. it does not have load-store architecture, as memory is directly referenced in arithmetic and logic operations
- ii. it has a singleton working register, whereas most modern architectures have significantly more

PIC have a set of register files that function as general purpose RAM, special purpose control registers for on-chip hardware resources are also mapped into the

data space. The addressability of memory varies depending on device series, and all PIC devices have some banking mechanism to extend the addressing to additional memory. Later series of devices feature move instructions which can cover the whole addressable space, independent of the selected bank. In earlier devices (ie. the baseline and mid-range cores), any register move had to be through the accumulator.

To synthesize indirect addressing, a "file select register" (FSR) and "indirect register" (INDF) are used: A read or write to INDF will be to the memory pointed to by FSR. Later devices extended this concept with post and pre increment/decrement for greater efficiency in accessing sequentially stored data. This also allows FSR to be treated like a stack pointer.

All PICs feature Harvard architecture, so the code space and the data space are separate. PIC code space is generally implemented as EPROM, ROM, or FLASH ROM. In general, external code memory is not directly addressable due to the lack of an external memory interface.

The PIC architecture has no (or very meager) hardware support for saving processor state when servicing interrupts. The 18 series improved this situation by implementing shadow registers which save several important registers during an interrupt.

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The PIC architecture may be criticized on a few important points.

- i. The few instructions, limited addressing modes, code obfuscations due to the "skip" instruction and accumulator register passing makes it difficult to program in assembly language, and resulting code difficult to comprehend. This drawback has been alleviated by the increasing availability of high level language compilers.
- ii. Data stored in program memory is space inefficient and/or time consuming to access, as it is not directly addressable.[6]

2.2.2 Voltage regulator circuit.

When the 9V through voltage regulator, the supply will be fixing to 5V and divide it to switch ON the PIC 16F877A and relays. The type of the voltage regulator is LM 7805 like Figure 2.8 and Figure 2.9. The features of LM 7805 are shown in data sheet at appendix.[7]

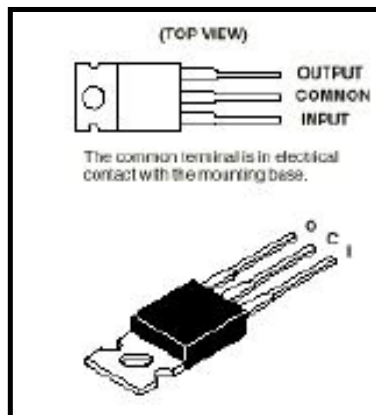


Figure 2.8: LM 7805

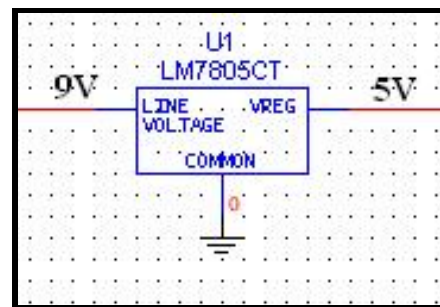


Figure 2.9: LM 7805 circuit

2.2.3 Relay

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered, in a broad sense, to be a form of an electrical amplifier. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts.

The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Usually this is a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to

operate quickly. In a low voltage application, this is to reduce noise. In a high voltage or high current application, this is to reduce arcing. The symbol circuit of relay and the relay are shown in figure 2.10 below: [6]

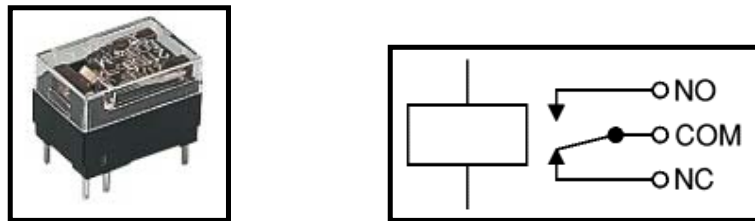


Figure 2.10: Relay and symbol circuit.

2.2.4 Darlington transistor array (ULN 20003A)

ULN 20003A is a high-voltage, high-current of Darlington transistor arrays. Each consists of seven npn Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of a single Darlington pair is 500 mA. The Darlington pairs can be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. Figure 2.11 and Figure 2.12 show the ULN2003A IC and logic diagram. Figure 2.13 show the circuit of Darlington arrays in the ULN2003A.[7]

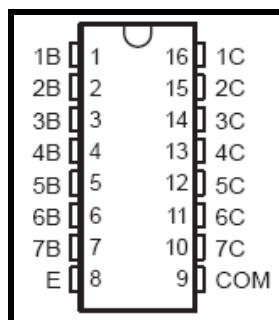


Figure 2.11:ULN2003A

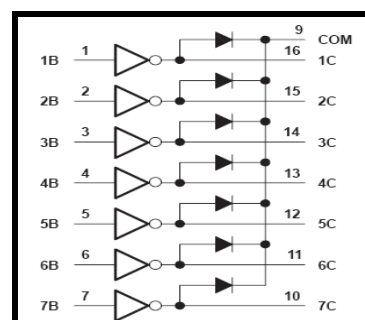


Figure 2.12: logic diagram

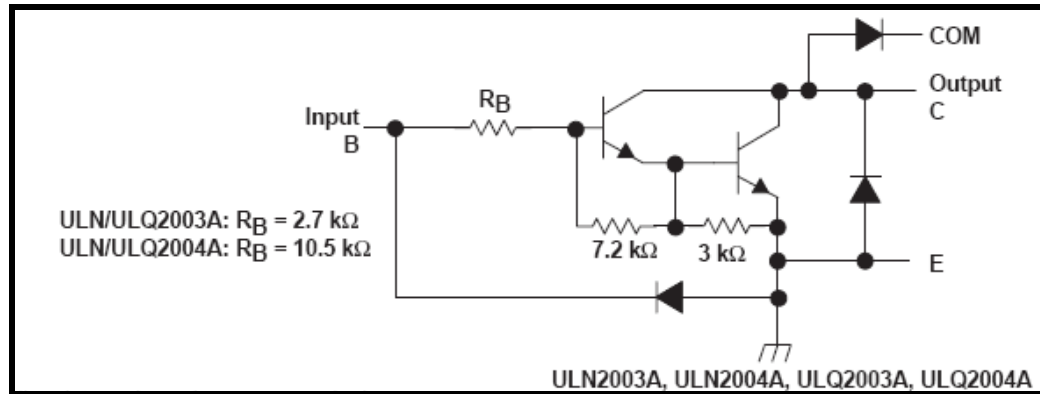


Figure 2.13: Darlington transistor circuit.

2.2.5 DC motor (automotive power window motor).

Motor will be use in this project for push back ELCB's spring trap and the spring trap actually very hard to push although by hand, so selection of motor important to make sure the ELCB's spring trap can be ON back automatically. The important characteristic that must be highlight is the motor torque and the suitable motor for make this happen is an automotive power window motor as shown in Figure 2.14 which is a DC motor type. Below are the specifications of the motor:

- i. Working voltage: 12V DC
- ii. No-load speed: 92rpm
- iii. No-load current: 1.30A
- iv. Stall torque: 9Nm
- v. Stall current: 24A
- vi. Water-resistant construction.[8]



Figure 2.14.: Automotive power window motor.

2.2.6 Current detectors.

There are several types of current detector such as current transducer, transtronics current detector and current transformer which are use for detected current by sensing the AC current. Figure 2.15 below is an example of current detector:

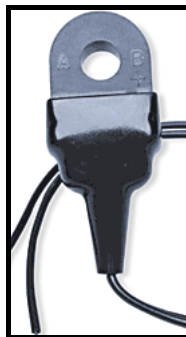


Figure 2.15: Current detector

Basically it gives us positive feedback whether the ELCB has current or not flow through it when it is in OFF condition. In this part the current detector that use is not like the example above but it function for detect current same as the current detector and actually it is a power supply which are use to step down the AC voltage then convert it to 5VDC voltage. Circuit diagram of it is on the appendix.

The power supply that use in this project as shown in figure above use a flyback converter and a bridge rectifier. The Flyback converter is a DC to DC converter with a galvanic isolation between the input and the output(s). More precisely, the flyback converter is a buck-boost converter with the inductor split to form a transformer, so that the voltage ratios are multiplied with an additional advantage of isolation. When driving for example a plasma lamp or a voltage multiplier the rectifying diode of the Buck-Boost converter is left out and the device is called a flyback transformer. This flyback transformer was apply to the 5VDC power supply as a transformer. Due to intrinsic limitations, this converter is only used in low power applications (up to about 250 W). Figure 2.16 below is a schematic diagram for flyback converter:

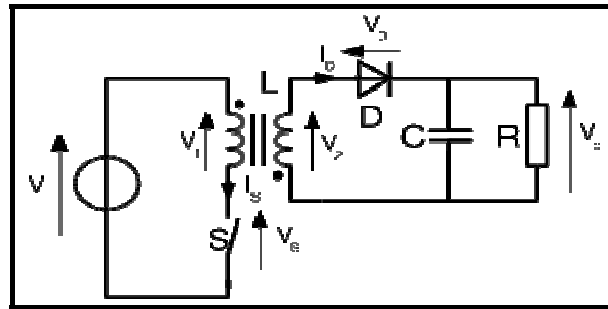


Figure 2.16: Schematic of flyback converter.

The bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification in the power supply. This is a widely used configuration, both with individual diodes wired and with single component bridges where the diode bridge is wired internally. Figure 2.17 below is a figure of full bridge rectifier:[9]

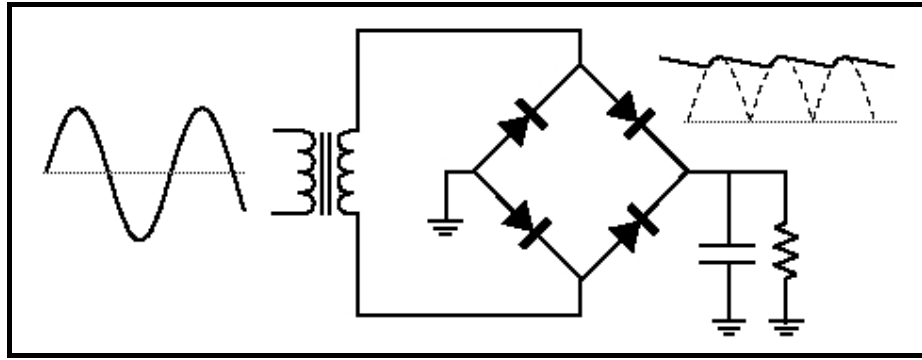


Figure 2.17: Full bridge rectifier circuit.

Current would be detected if there has a voltage from TNB power supply to a load, so based from the voltage law, if current want to be detected, thus $I = V/R$. The 5VDC power supply almost like a cell phone charger which is produce 5VDC and current 500mA. It would be connected series with the life wire from TNB then the output, 5VDC would be connected to microcontroller, PIC16F877A as an input.

2.3 Software part

Software part will discuss about the software that would be used for designing and simulating circuit of the project and this part is the very important part where it decisive how to start the project. After the designing and simulating the project circuit success, then the real circuit would be made based on it. Actually there are three software assist to make this project:

- i. ISIS PROFESSIONAL (designing simulating circuit).
- ii. PCW C COMPILER (PIC programming for C language).
- iii. MELABS PROGRAMMER (PIC program's burner)

2.3.1 ISIS PROFESIONAL software

Many CAD users dismiss schematic capture as a necessary evil in the process of creating PCB layout. With PCB layout now offering automation of both component placement and track routing, getting the design into the computer can often be the most time consuming element of the exercise.

ISIS has been created with this in mind and Figure 2.18 shows the Proteus ISIS window. It has evolved over twelve year's research and development and has been proven by thousands of users worldwide. The strength of its architecture has allowed us to integrate first conventional graph based simulation and now - with PROTEUS VSM - interactive circuit simulation into the design environment. For the first time ever it is possible to draw a complete circuit for a micro-controller based system and then test it interactively, all from within the same piece of software. Meanwhile, ISIS retains a host of features aimed at the PCB designer, so that the same design can be exported for production with ARES or other PCB layout software.

For the educational user and engineering author, ISIS also excels at producing attractive schematics like you see in the magazines. It provides total control of drawing appearance in terms of line widths, fill styles, colors and fonts. In addition, a system of templates allows you to define a 'house style' and to copy the appearance of one drawing to another.

Other general features include:

- i. Runs on Windows 98/Me/2k/XP and later.
- ii. Automatic wire routing and dot placement/removal.
- iii. Powerful tools for selecting objects and assigning their properties.
- iv. Total support for buses including component pins, inter-sheet terminals, module ports and wires.
- v. Bill of Materials and Electrical Rules Check reports.
- vi. Netlist outputs to suit all popular PCB layout tools.